PATHFINDER

Introducing Solar-Powered Aircraft
for
Observing the Environment
Without Disturbing Nature

Imagine...

An aircraft that could stay aloft all day, powered only by sunlight.
An aircraft that is no more than a flying wing, able to maneuver without rudders, ailerons, tails, or other control surfaces typical of conventional aircraft.
An aircraft that flies without an onboard human pilot, and is controlled remotely from a ground station.
Imagine the Pathfinder.

Pathfinder

The NASA Pathfinder aircraft, designed and built by AeroVironment Inc., for the NASA Environmental Research Aircraft and Sensor Technology (ERAST) Program, is a lightweight, remotely-piloted, solar-powered aircraft weighing less than 600 lb. Pathfinder is a proof-of-concept forerunner for the Centurion and its successor, the Helios Prototype aircraft.

Pathfinder is constructed of state-of-the-art composites, plastics, and foam. The upper surface of the aircraft's 100-ft wing is covered almost completely by thin solar-cell arrays that collect sunlight and convert it into electricity. This electricity powers six small motors with propellers. Slowing down or speeding up these individual propellers allows Pathfinder to make turns, since it does not have ailerons and rudders typical of most airplanes.

Pathfinder Flight History

Pathfinder was developed in the early 1980s, and was adopted into NASA's ERAST Program in 1993. After initial flight tests at NASA Dryden Flight Research Center, at Edwards, CA, it was modified with additional solar arrays and other upgrades. Another series of development flights began in 1995. On September 11, 1995, Pathfinder reached an altitude of 50,500 ft, setting a new altitude record for solar-powered aircraft.

After more upgrades and one checkout flight at Dryden in late 1996, Pathfinder was deployed to the U.S. Navy's Pacific Missile Range Facility (PMRF) at Barking Sands, Kauai, HI, in April 1997. Kauai was chosen as an optimum location for testing the solar-powered Pathfinder due to its high levels of sunlight, available airspace and radio frequencies, and the diversity of terrestrial and coastal ecosystems for validating scientific imaging applications. While in Hawaii, Pathfinder flew seven high-altitude missions from PMRF. By this time it was clearly the world's highest-flying solar-powered aircraft. With a flight to 71,530 ft Pathfinder had also flown higher than any other propeller-driven aircraft.

Pathfinder Plus

Essentially a transitional vehicle, the Pathfinder Plus was a hybrid of the technology employed on Pathfinder and developed for the Centurion/Helios Prototype.

During 1998, the Pathfinder was modified into the longer-winged Pathfinder Plus configuration. On August 6, 1998, the Pathfinder Plus was flown to an altitude of approximately 80,200 ft, again setting new standards for solar-powered and propeller-driven aircraft. The goal of the flights was to validate new solar, aerodynamic, propulsion, and systems technologies developed for the Pathfinder's successor, the Centurion/Helios Prototype.

The most noticeable change in the Pathfinder Plus was the installation of a center wing section that incorporated a high-altitude airfoil designed for Centurion. The new section was twice as long as the original Pathfinder center section and increased the overall wingspan of the craft from 98.5 to 121 ft. The new center section was topped by more efficient silicon solar cells that could convert 19 percent of the solar energy they receive into useful electrical energy to power the craft's motors, avionics, and communication systems. Maximum potential power was boosted from about 8,000 kW on

Pathfinder to about 12,500 kW on Pathfinder Plus. Pathfinder's six motors were replaced by motors designed for the Centurion, and two additional motors were mounted on the center section of the wing.

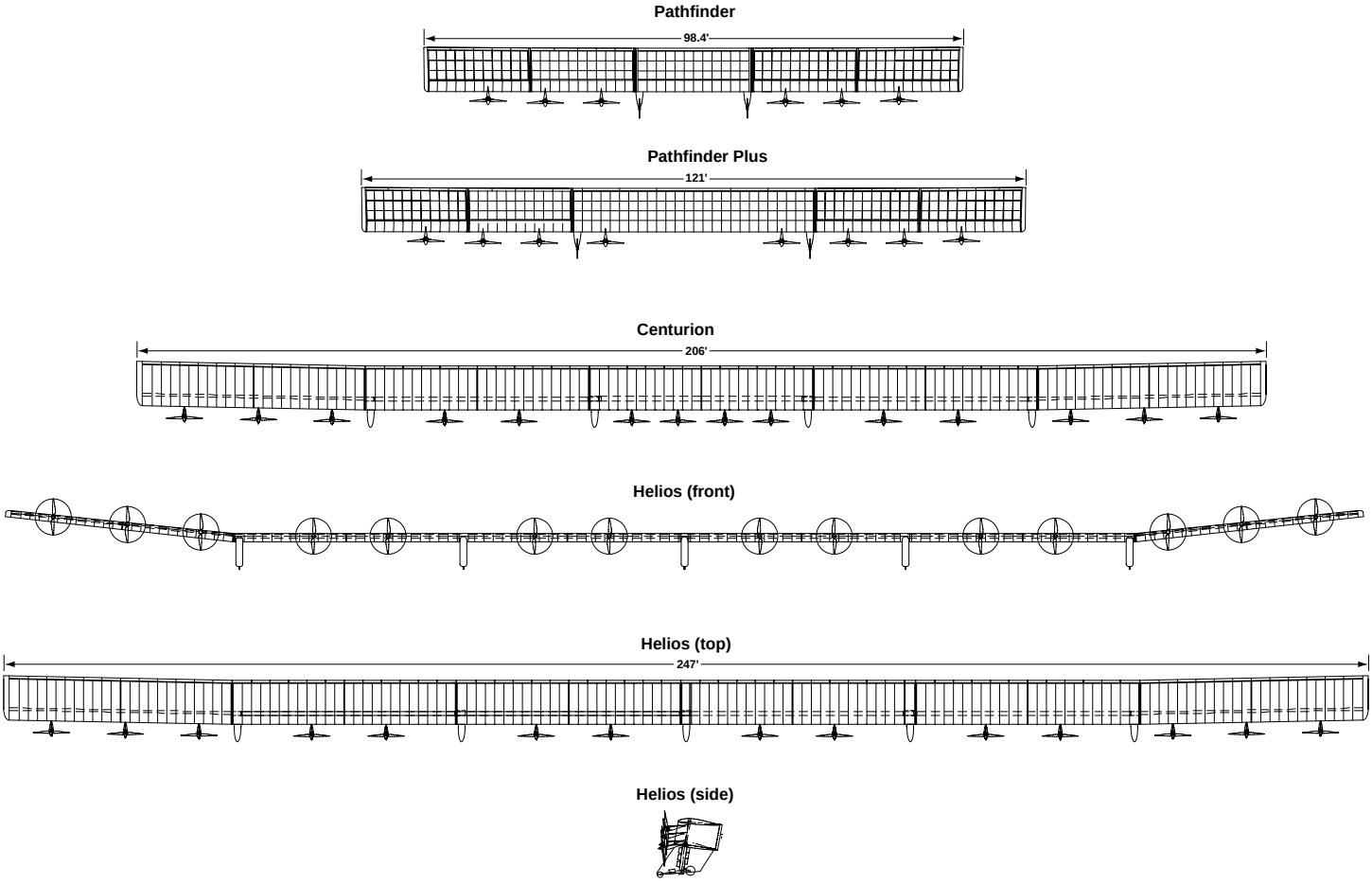
Centurion/Helios Prototype

Centurion began flying in 1998. It had a wingspan of 206 ft, was powered by 14 electric motors, and had an empty weight of only 1,175 lb. In 1999 Centurion became the Helios Prototype after undergoing modifications increasing its wingspan to 247 ft. The Helios Prototype is designed to reach an altitude of 100,000 ft, as well as demonstrate the ability to fly for 96 consecutive hours.

Helios

The Pathfinder/Centurion/Helios series of aircraft are designed to carry a payload of scientific sensors that may be used for a variety of monitoring purposes while flying at extremely high altitudes. They fly much slower than most aircraft, with cruising speeds of only about 20-27 mph. The slower a vehicle flies, the greater its ability to capture samples of the atmosphere without altering them. NASA is especially interested in these vehicles for their ability to study the upper atmosphere without disturbing it. Helios will use an energy storage system to power the aircraft at night. The solar cells power the vehicle during the day and recharge the energy storage system for use at night. The duration of such flights could be indefinite, making Helios suitable for missions that were previously impossible for an aircraft. It could:

- Spend long periods of time over the ocean monitoring storm developments to provide more accurate predictions of hurricanes.
- Monitor coral reefs to determine damage caused by humans.
- Monitor forest life to provide early warning of crop damage or fires.
- Serve as a surrogate satellite when regular satellite coverage is not available.



Classroom Activity–Pathfinder on a String

In this activity you will construct a model of the Pathfinder aircraft that really flies.

Materials needed per student

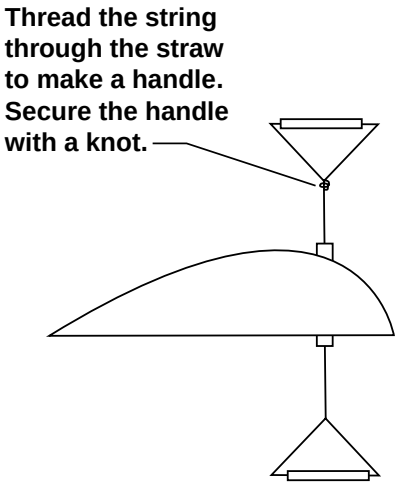
- One meter of string or fishing line
- One drinking straw
- Transparent tape
- One sheet of letter-size paper, with template copy
- Scissors

Construction Procedure

1. Distribute the materials.
2. Students will follow the four steps marked on the template:

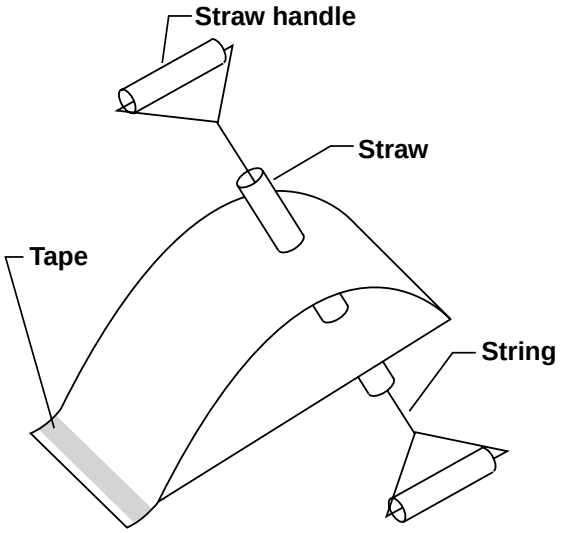
   Step One. Make a pencil-size hole in copy of template marked Step 1.
   Step Two. Make a pencil-size hole in copy of template marked Step 2.
   Step Three. Fold along the line marked Step 3, and keep folded.
   Step Four. Align the 8.5" edges and tape them together.

3. Cut straw into three equal pieces, approximately 5 cm long.
4. Insert one of the straw pieces through both holes (see picture).
5. Thread the string through the straw to create the Pathfinder on a String.
6. Use the other two pieces of the straw for handles (see picture).



Flying your Pathfinder on a String

Hold the straw handles, with your arms straight out, so the string through the wing is parallel perpendicular to the ground. This forward motion will cause air to flow over and under the Pathfinder creating *lift* and a flying model. Flying Pathfinder on a String can be done indoors or outdoors.



Explanation

The Pathfinder is a giant *airfoil*. What you have done is built an airfoil model on a string. When you fly your Pathfinder model, the shape of the airfoil creates lift. Lift is created when slow moving air molecules under the wing create high pressure, and fast moving air molecules above the wing create low pressure. There are many other factors that affect the flight of your airfoil. As you walk forward, your motion is creating the *thrust* that moves the airfoil forward. The forces of *drag* and *gravity* are other forces that act upon the flight of your Pathfinder on a String.

Extensions

- Attach paper clips (adding weight) to the airfoil trailing edge of the airfoil and observe its flight characteristics.
- Fly Pathfinder on a String in front of a fan.
- Experiment with different sizes of paper for the airfoil.

Step 4. Tape along this line

Step 1. Punch hole with pencil

Step 3. Fold along this line

Step 2. Punch hole with pencil

The cover of this poster
is a stylized look at a Pathfinder reseach flight and the promise
of solar-powered aircraft like Helios.

The night sky represents flights that continue 24 hours a day.

Pathfinder, backlit by the sun, cruises in the stratosphere, above the highest clouds.

Hurricanes and other destructive weather systems in the troposphere are safely observed from above.

Hawaii was one of the first regions to be studied by Pathfinder. Aerial photographs of the tropics can help farmers monitor the health of crops like sugar cane (background, center).

High-altitude observation of the ocean helps us understand how humans are affecting the undersea ecosystem.

Pathfinder Web Sites

Pathfinder Mission Updates

http://www.dfrc.nasa.gov/Projects/Erast/pathfinder.html

Pathfinder Movies

http://www.dfrc.nasa.gov/gallery/movie/Pathfinder/index.html

Pathfinder Remote Sensing Images

http://geo.arc.nasa.gov/ERAST/pathfinder/index.html

http://hawkeye.arc.nasa.gov/ERAST/

Remote Sensing Map of Kauai, HI

http://hawkeye.arc.nasa.gov/cgi-bin/pathfindermap?/kauai

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AT Home Page

http://www.aero-space.nasa.gov/

NASA Spacelink

NASA Spacelink is one of NASA's electronic resources specifically developed for the educational community. Spacelink is the official home to electronic versions of NASA's Education Products, and includes links to other education resources.

http://spacelink.nasa.gov

NASA Education Home Page

Information about all of the NASA Education Programs.

http://education.nasa.gov/

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EW-1999-04-003-DFRC